DOCUMENTED CHROMOSOME NUMBERS 1993:2. ADDITIONAL CHROMOSOME COUNTS IN THE MALVACEAE

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ABSTRACT

Chromosome numbers are reported for 29 species of Malvaceae in 13 genera, of which 18 are new reports. The taxonomic implications of these data are discussed.

RESUMEN

Se reporta números cromosómicos para 29 especies de las malváceas en 13 géneros, de las cuales 18 son datos nuevos. La significación taxonómica de estos datos está considerado.

INTRODUCTION

Chromosome numbers have been useful in evaluating generic boundaries and generic and tribal relationships in many families, including the Malvaceae (Bates 1966, 1968, 1976; Bates and Blanchard 1970; Krapovickas 1957, 1969). The opportunity to obtain new counts and verify previous counts (Table 1) permits the extension and revision of previous interpretations of relationships within the Malvaceae.

MATERIALS AND METHODS

All counts were made on samples taken from greenhouse-grown plants, grown from seed samples taken from voucher specimens indicated in Table 1. Voucher specimens are kept in the senior author's herbarium in College Station, Texas; additional duplicates of these collections may also be found in other herbaria, as noted in the table.

Floral buds were fixed in 3:1, 95% ethanol: glacial acetic acid, for a minimum of 24 hr. Prior to preparation of specimens, the buds were rinsed and allowed to

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TABLE 1. Chromosome numbers of selected species of Malvaceae. New counts are indicated with an asterisk (*).

Species	2*n*	Origin	Voucher
Abutilon barrancae M.E. Jones Torrey ex Gray	16*	Mexico. Nayarit	*Téllez 12703*, MEXU
Abutilon hulseanum (Torr. & Gray)	14	Mexico. Veracruz	*Tenorio 8588*, MEXU
Abutilon macvaughii Fryx.	14*	Mexico. Jalisco	*Lott 4008*, UCR
Abutilon otocarpum F. Muell.	14*	Australia	*Fryxell 3855*, CANB
Abutilon parishii S. Watson	14*	U.S.A. Arizona	*Van Devender et al. 91-808*, ARIZ
Abutilon sphaerostaminum Hochr.	14*	Mexico. Veracruz	*Nee & Taylor 28790*, NY
Allowissadula floribunda (Schltdl.) Fryx.	16	Mexico	*Jones & Treviño 168*, NY
Anoda abutiloides A. Gray	30	U.S.A. Arizona	*Van Devender et al. 91-959*, ARIZ
Anoda albiflora Fryx.	30*	Mexico. Michoacán	*Fryxell 5012*, NY
Anoda palmata Fryx.	30	Mexico. Jalisco	*Koch & Fryxell 89193*, CHAPA
Batesimalva killipii Krapov.	24*	Venezuela	*Fryxell & Burandt 4393*, F
Batesimalva violacea (Rose) Fryx.	32*	U.S.A. Texas	*Wurdack s.n.*
Cienfuegosia intermedia Fryx.	20*	Mexico. San Luis Potosí	*Jones 147*, NY
Cienfuegosia ulmifolia Fryx.	20	Argentina	*Schulz s.n.*, CTES
Dirhamphis mexicana Fryx.	30*	Mexico. Jalisco	*Lott et al. 4042*, UCR
Fryxellia pygmaea (Corr.) Bates	16	Mexico. Coahuila	*Fryxell 5006*, NY
Hibiscus calyphyllus Cav.	80	Hawaii. Kauai	without coll., seed acc. no. 74s723, Waimea B.G.
Hibiscus citrinus Fryx.	22*	Mexico. Jalisco	*Lott et al. 4083*, UCR
Hibiscus grandidieri Baillon	32*	Madagascar	*Hardy s.n.*, NY
Hibiscus panduriformis Burm. fil.	24	Australia	*Fryxell 4550*, CANB
Hibiscus pentaphyllus F. Muell.	36*	Australia	*Fryxell 4431*, CANB
Horsfordia exalata Fryx.	30*	Mexico. Sonora	*Sanders 4620*, UCR
Pavonia ecostata Fryx. & Koch	56*	Mexico. Jalisco	*Koch & Fryxell 89198*, CHAPA
Phymosia umbellata (Cav.) Kearn.	34	Mexico. Tamaulpas	*Fryxell 4959*, NY
Sida argentina var. *tucumanensis* Hassler ex Rodrigo	14*	Argentina. Salta	*Cristóbal 2079*, CTES
Sida lindheimeri Engelm. & Gray	28	U.S.A. Texas	*Fryxell 4964*, BRIT
Sida rohlenae var. *mutica* (Benth.) Fryx.	14*	Australia	*Fryxell 4428*, CANB
Sphaeralcea ambigua A. Gray	30	U.S.A. California	*Pitzer 197*, UCR
Sphaeralcea reflexa Fryx. et al.	20*	Mexico. Coahuila	*Fryxell et al. 4997*, TEX

soak in tap water or distilled water for several hours. Anthers were dissected from the buds, placed in acetocarmine stain, then cut and macerated to release microsporocytes. Preparations containing microsporocytes at stages suitable for chromosome counting were covered with a coverslip and repeatedly heated and cooled until chromatin was satisfactorily stained. The cells were then squashed, and the coverslips were sealed with wax. Counts were made under oil immersion brightfield or, occasionally, phase-contrast optics on an Olympus Vanox microscope. Sufficiently flat specimens were photographed using Kodak Technical Pan film 2415.

RESULTS AND DISCUSSION

The results of these studies are summarized in Table 1.

Abutilon. Chromosome counts for six species are reported in the genus *Abutilon* (Figs. 1, 2). A previous count for *A. hulseanum* (Bates 1976) is verified, and new reports are presented for the remaining five species. Four of these five have a chromosome number of $2n = 14$, which conforms to the base number of $x = 7$ for the majority of species in the genus. *Abutilon barrancae*, on the other hand, has $2n = 16$. This species represents *Abutilon* sect. *Anasida* (cf. Fryxell 1988, p. 25). Those species that have been or can be placed in this section, and which have been counted, also have chromosome numbers of $2n = 16$, including *Abutilon*

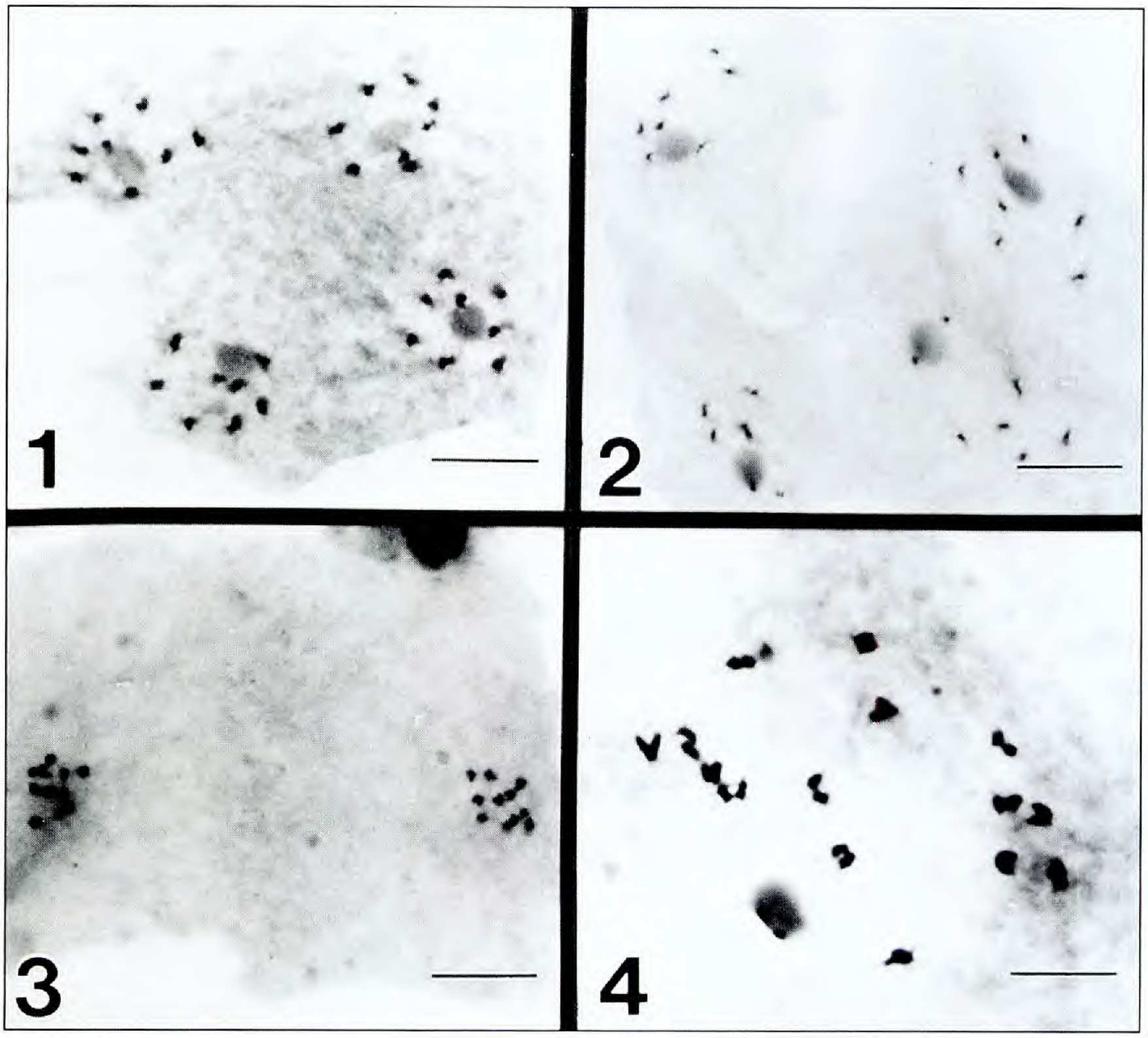


FIG. 1. Microsporocyte of *Abutilon barrancae*: coenocytic sporad stage, showing four nuclei, each with eight chromosomes (bar = 18 µm).

FIG. 2. Microsporocyte of *Abutilon parishii*: coenocytic sporad stage (at early cytokinesis), showing four nuclei, each with seven chromosomes (bar = 20 µm).

FIG. 3. Microsporocyte of *Hibiscus citrinus*: coenocytic dyad stage, each of the two poles having 11 chromosomes (bar = 20 µm).

FIG. 4. Microsporocyte of *Hibiscus grandidieri*: diplotene stage with 16 bivalents, one closely associated with the darkly staining nucleolus (bar = 15 µm).

anderssonianum Garcke, *A. ellipticum* Schltdl., *A. thurberi* A. Gray, *A. umbellatum* (L.) Sweet, *A. virgatum* (Cav.) Sweet, and *Pseudabutilon callimorphum* (Hochr.) R.E. Fries (Bates 1966, 1976; Fernández 1974; Krapovickas 1957). This group of species is clearly distinguished cytologically, a distinction that is supported by morphological characters, and the question must be raised whether sect. *Anasida* merits elevation to generic rank. If so, the name *Pseudabutilon* is available, although several new combinations would be required, and the generic boundaries originally proposed by Fries (1908) would have to be revised. The typification of *Pseudabutilon* was discussed by Fryxell (1988, p. 75), who concluded that the type species is *Pseudabutilon scabrum* (Presl) R.E. Fries [= *Abutilon barrancae* M.E. Jones].

Another group of *Abutilon* species is characterized by a chromosome number of $2n = 16$ (e.g. *A. inaequilaterum* St.-Hil., *A. mueller-friderici* Gürke & Schumann, *A. niveum* Griseb., *A. pictum* (Hooker & Arnott) Walp., *A. purpusii* Standley, *A. regnellii* Miquel, and *A. striatum* Dicks. ex Lindl.), but these may be assigned to *Abutilon* sect. *Pluriovulatae* Fryx. and are outside of the present discussion.

Allowissadula. The count of $2n = 16$ for *Allowissadula floribunda* confirms the previously reported chromosome number for this species (Bates 1978, as *A. microcalyx* (Rose ex R.E. Fries) Bates). Of the nine species of this genus, five are known cytologically, all of which have the same chromosome number.

Anoda. The three species of *Anoda* reported here all have the chromosome number $2n = 30$, which conforms to the known base number for the genus, $x = 15$ (Bates 1987). The values for *A. abutiloides* (Fig. 5) and *A. palmata* are confirmations of previously reported counts (Bates 1987), and the report for *A. albiflora* is new. The latter species is polymorphic for corolla color, and the available seed sample was segregating for white- and lavender-flowered plants. Both flower color forms have the same chromosome number.

Batesimalva. The count of $2n = 32$ for *B. violacea* is new (Figs. 9, 10). Only one previous chromosome count in *Batesimalva* has been reported, also $2n = 32$ for *B. pulchella* Fryx. (Bates and Blanchard 1970, as *Gaya* aff. *violacea*). This species is very similar to *B. violacea*, both morphologically and phytogeographically.

The count of $2n = 24$ for *B. killipii* is also new (Fig. 13) and presents a number that is seldom encountered in the Malvaceae. In the tribe Malveae, counts of $2n = 12$ and 24 have been reported principally in the genera *Gaya* (Krapovickas 1957; Fernández 1974, 1981; Bates 1976) and *Malvastrum* (Hill 1982), as well as from a few species of *Cristaria* (Krapovickas 1957) and *Lecanophora* (Krapovickas 1950). *Batesimalva killipii* cannot be allied with any of these genera, differing substantially from all of them in morphological terms.

At the same time, the chromosome count of $2n = 24$ for *Batesimalva killipii* differs from the counts of $2n = 32$ reported for other species of *Batesimalva* (see previous paragraph), and the two counts are not readily reconciled. Therefore, the generic placement of *B. killipii* is brought into question. The species was

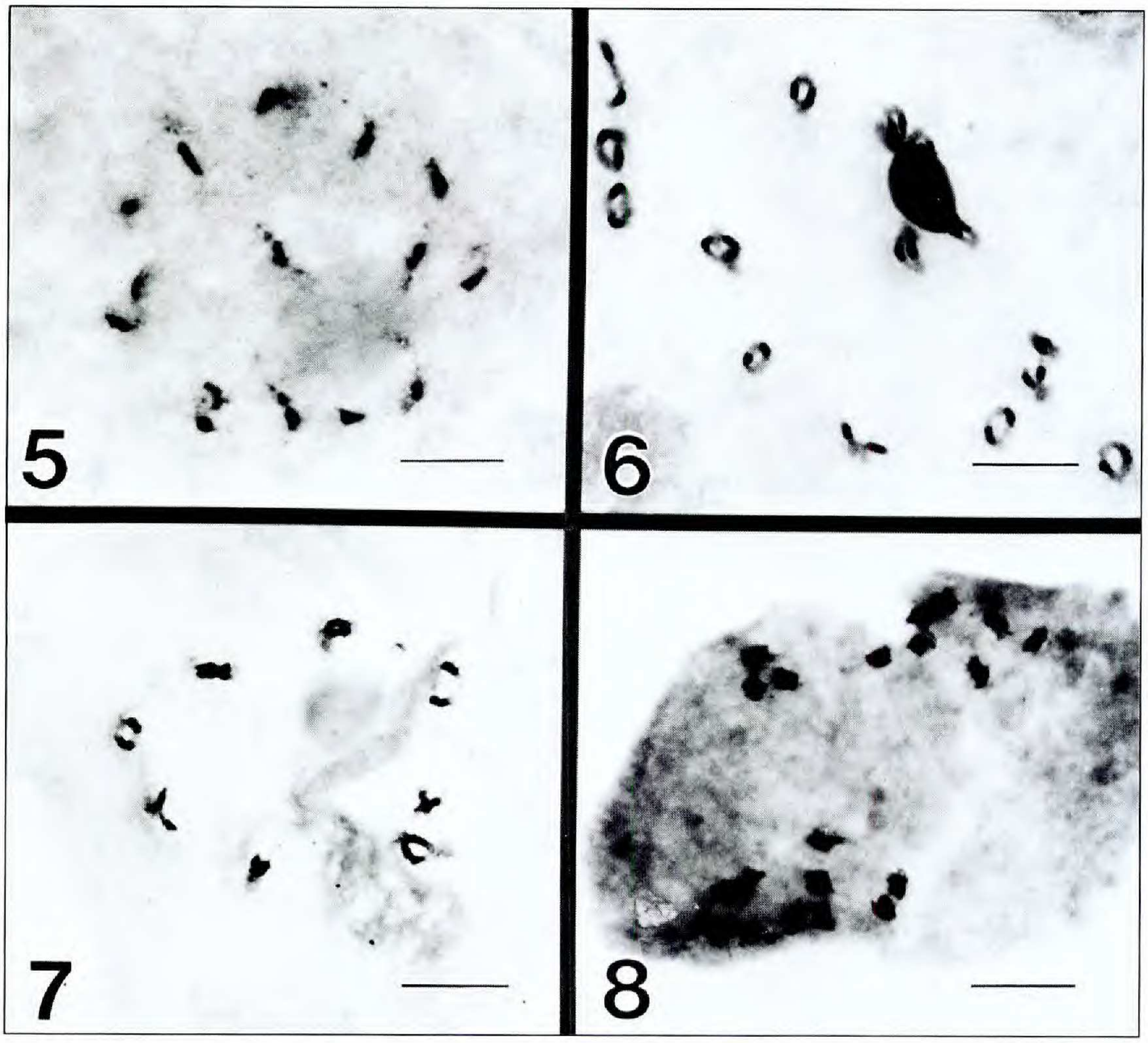


FIG. 5. Microsporocyte of *Anoda abutiloides*: late diplotene stage (nucleolus barely visible), with 15 bivalents at unusual semi-contracted state (bar = 9 μm).

FIG. 6. Microsporocyte of *Dirhamphis mexicana*: diplotene stage, showing 15 bivalents, three attached or partially superimposed on the nucleolus (bar = 16 μm).

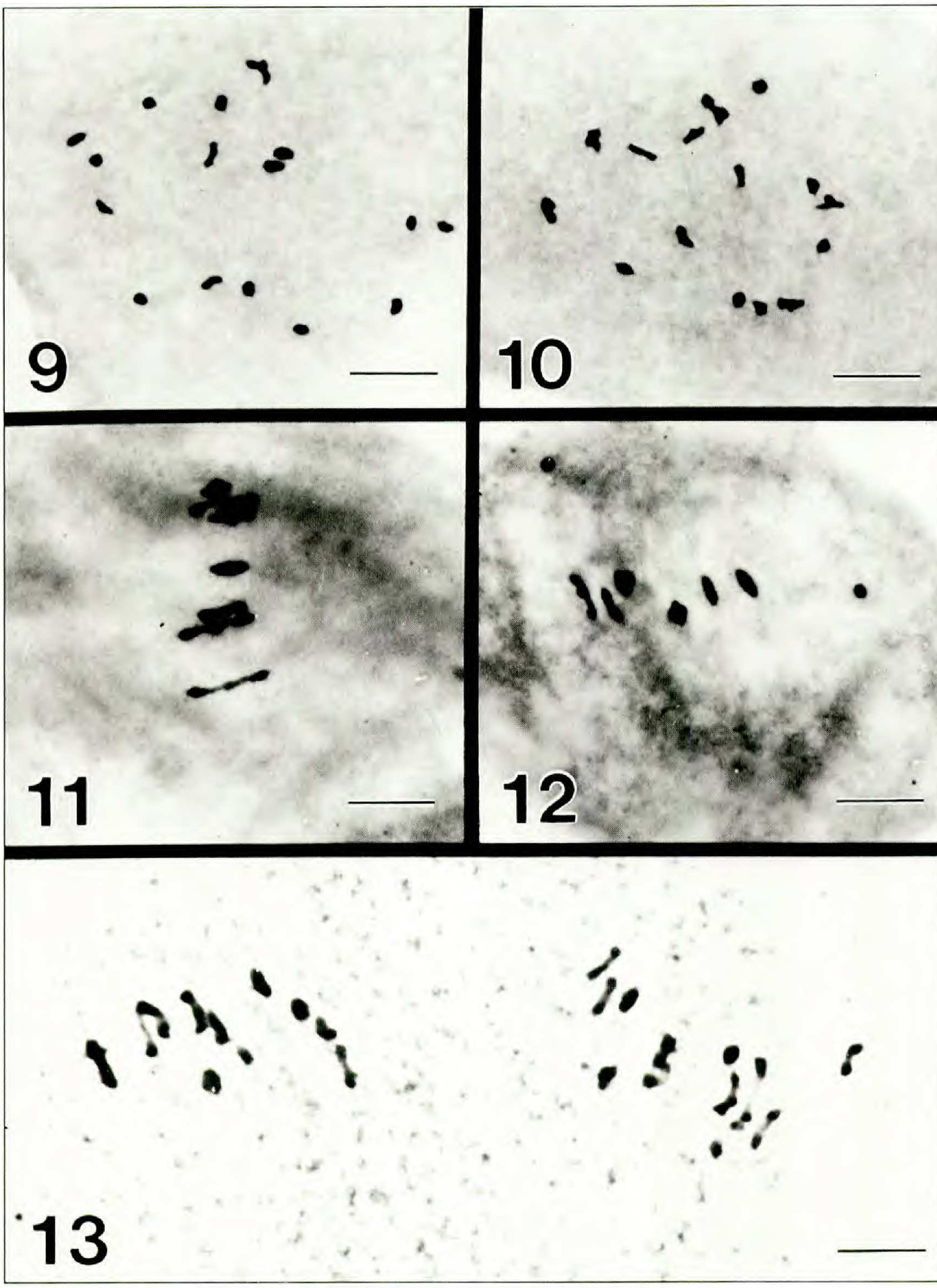
FIG. 7. Microsporocyte of *Fryxellia pygmaea*: diplotene stage, showing 8 bivalents (bar = 16 μm).

FIG. 8. Microsporocyte of *Sphaeralcea reflexa*: telophase I, each pole with 10 chromosomes (bar = 12 μm).

originally placed in *Batesimalva* because it shared features of mericarp morphology with previously known species of the genus, although it differed in floral (and other) characters and in phytogeography. In view of the cytological difference here reported, the generic boundaries of *Batesimalva* will need to be reconsidered, including the possibility of a new generic placement for *B. killipii*.

Cienfuegosia. The chromosome counts of $2n = 20$ for *C. intermedia* is a new report, and the same count for *C. ulmifolia* confirms the report of Palacios and Tiranti (1966). These counts agree with the numbers reported for other American species of this genus that are cytologically known (Wilson and Fryxell, 1970).

Dirhamphis. The chromosome number of $2n = 30$ (Fig. 6) reported here for



FIGS. 9 and 10. Microsporocytes of *Batesimalva violacea*: early metaphase I, with 16 bivalents (bar = 18 µm).

FIGS. 11 and 12. Microsporocytes of *Sida rohlenae* var. *mutica*: *metaphase* I, with seven bivalents (four "rods" and three "rings") vs. six bivalents (one rod) plus two univalents (off metaphase plate), respectively (bars = 11µm and 13 µm, respectively).

FIG. 13. Two microsporocytes of *Batesimalva killipii*: metaphase I, each with 12 bivalents (bar = 8.9 µm).

D. mexicana is a new report. The other species of the genus, *D. balansae* Krapov., has been reported as $2n = 14$ (Fernández 1981). Fryxell (1988, p. 6) suggested that a group of four genera (*Batesimalva, Horsfordia, Briquetia*, and *Dirhamphis*) constitute a generic alliance, based largely on a commonality in fruit structure, but this view may need to be revised on the basis of chromosome numbers reported here, as discussed further in the following paragraph. Further, because of disparate chromosome numbers, the two species of *Dirhamphis* may not be congeneric.

Fryxellia. The count of $2n = 16$ for *F. pygmaea* (Fig. 7) was previously reported (Fryxell and Valdés 1991) and the cell preparations illustrated. It was suggested that a phylogenetic relationship may exist between *Fryxellia* and *Batesimalva*, which possibly share a common base chromosome number. This finding provides a hypothesis for evaluation using other classes of data. Moreover, the other genera noted above also need to be brought into the discussion. On the basis of chromosome numbers now available, this group may need to be divided into at least two groups, one with $x = 15$ (*Dirhamphis mexicana* and *Horsfordia*) and one with $x = 16$ (*Batesimalva*) or $x = 8$ (*Fryxellia*). *Briquetia* ($x = 7$) may not relate to either group but may be better placed in the *Abutilon* alliance. The position of *Dirhamphis mexicana* and that of *Batesimalva killipii* require further study, but we now have a framework for discussion.

Hibiscus. Chromosome counts for five species are reported here, three of which are new. Previous reports for *Hibiscus panduriformis* (Skovsted 1941; Dasgupta and Bhatt 1976, 1982; Bhatt and Dasgupta 1976; Krishnappa and Munirajappa 1980) have all given the same result as found here, $2n = 24$, even though this species is highly variable morphologically. The count of $2n = 80$ for *H. calyphyllus* conforms to previous counts reported by Skovsted (1941), Niimoto (1966), Kachecheba (1972) and Krishnappa & Munirajappa (1980), but differs from a report of $2n = 40$ by Bates (1966); the species evidently exists at two ploidy levels.

The count of $2n = 22$ for *H. citrinus* (Fig. 3) conforms to similar counts reported for other New World species of *Hibiscus* sect. *Bombicella*, *H. biseptus* S. Wats., *H. denudatus* Benth., *H. martianus* Zucc., and *H. phoeniceus* Jacq. (Skovsted 1935, 1941; Bates 1976), indicating that the American members of this section are cytologically quite uniform.

Chromosome numbers for *Hibiscus* sect. *Bombicella*, the section to which *H. grandidieri* belongs, were reviewed by Fryxell (1980). The count here reported (Fig. 4) for *H. grandidieri* ($2n = 32$) conforms to counts for two other African species of this section (*H. mutatus* N.E. Brown and H. *ferrugineus* Cav.) but differs from the tetraploid count $2n = 64$ for *H. micranthus* L. f. and the count of $2n = 22$ for *H. pusillus* Thunberg. The latter count is the same as that which characterizes the five American species of section *Bombicella* that are known cytologically (Fryxell 1980; see previous paragraph).

The count of $2n = 36$ for *H. pentaphyllus* conforms to the count reported for the similar species *H. caesius* Garcke (Dasgupta and Bhatt 1976, 1982). However, the base chromosome number of $x = 18$ is also characteristic of *Hibiscus* sect. *Furcaria*, where it is known at several ploidy levels (e.g., Menzel & Wilson 1969), a group of species to which *H. pentaphyllus* is clearly not closely related.

Thus it is clear that much remains to be learned about the generic subdivision of *Hibiscus*, a genus of considerable cytological polymorphism.

Horsfordia. This genus contains five species, two of which (*H. alata* (Wats.) Gray and *H. newberryi* (Wats.) Gray) have been reported previously to have 2n = 30 (Bates 1966, 1976), as is reported here for *H. exalata*. The genus appears to be uniform, and it shares a base chromosome number of $x = 15$ with *Dirhamphis mexicana*, as discussed previously.

Pavonia. Chromosome counts for more than 25 species of *Pavonia* have been reported in the literature (Fryxell, in prep.), and all have been at various ploidy levels based on $x = 7$. The new count for *P. ecostata* of $2n = 56$ conforms to this pattern and indicates the species is octoploid. This is the only count yet reported for *Pavonia* subgen. *Malache*. *Pavonia* and *Hibiscus* present an interesting contrast. Both are large genera with more than 200 species, but *Pavonia* is cytologically uniform with a single base number, whereas *Hibiscus* is highly polymorphic with a wide range of base numbers.

Phymosia. The report of $2n = 34$ for *Phymosia umbellata* confirms previous reports for this species (Bates 1976; Skovsted 1935; Webber 1936) and previous counts for other species in the genus, *P. rosea* (DC.) Kearn. (Bates and Blanchard 1970) and *P. abutiloides* (L.) Hamilton (Webber 1936).

Sida. Two of the three counts reported here for *Sida* are new reports. Both *Sida argentina* var. *tucumanensis* and *Sida rohlenae* var. *mutica* have $2n = 14$ (Figs. 11, 12), the most common count reported for species of *Sida*. The tetraploid count of $2n = 28$ for *Sida lindheimeri* confirms a previous count (Krapovickas 1969).

Sphaeralcea. A base chromosome number of $x = 5$ characterizes this genus, and counts of $2n = 10, 20,$ and 30 have been reported for various species, including *S. ambigua*, reported here as having $2n = 30$. The count of $2n = 20$ for *S. reflexa* is a new report (Fig. 8).

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REFERENCES

BATES, D.M. 1966. Chromosome numbers in the Malvales. I. Gentes Herb. 10:1–116.

BATES, D.M. 1968. Generic relationships in the Malvaceae, tribe Malveae. Gentes Herb. 10:117–135.

BATES, D.M. 1976. Chromosome numbers in the Malvales. III. Miscellaneous counts from the Byttneriaceae and Malvaceae. Gentes Herb. 11:143–150.

BATES, D.M. 1978. *Allowissadula*, a new genus of North American Malvaceae. Gentes Herb. 11:329–354.

BATES, D.M. 1987. Chromosome numbers and evolution in *Anoda* and *Periptera* (Malvaceae). Aliso 11:523–531.

BATES, D.M. and O.J. BLANCHARD, JR. 1970. Chromosome numbers in the Malvales II. New or otherwise noteworthy counts relevant to classification in the Malvaceae, tribe Malveae. Amer. J. Bot. 57:927–934.

BHATT, R.P. and A. DASGUPTA. 1976. Cytotaxonomy of Malvaceae I. Chromosome number and karyotype analysis of *Hibiscus, Azanza*, and *Urena*. Cytologia 41:207–217.

DASGUPTA, A. and R.P. BHATT. 1976. IOPB chromosome number reports. Taxon 25:494.

DASGUPTA, A. and R.P. BHATT. 1982. Cytotaxonomy of Malvaceae III. Meiotic studies of *Hibiscus, Abelmoschus, Azanza, Thespesia, Malachra, Urena*, and *Pavonia*. Cytologia 47:109–116.

FERNANDEZ, A. 1974. Recuentos cromosómicos en Malváceas. Bol. Soc. Argent. Bot. 15:403–410.

FERNANDEZ, A. 1981. Recuentos cromosómicos en Malvales. Bonplandia 5:63–71.

FRIES, R.E. 1908. Entwurf einer Monographie der Gattungen *Wissadula* und *Pseudabutilon*. Kongl. Svenska Vetenskapsakad. Handl. 43(4):1–114 + 10 plates.

FRYXELL, P.A. 1980 A revision of the American species of *Hibiscus* section *Bombicella* (Malvaceae). Techn. Bull. U.S. Dept. Agric. 1624 (pp. 1–53).

FRYXELL, P.A. 1988. Malvaceae of Mexico. Syst. Bot. Monogr. 25:1–522.

FRYXELL, P.A. and J. VALDÉS R. 1991. Observations on *Fryxellia pygmaea* (Malvaceae). Sida 14:399–404.

HILL, S.R. 1982. A monograph of the genus *Malvastrum* A. Gray (Malvaceae: Malveae). Rhodora 84:1–83, 159–264, 317–409.

KACHECHEBA, J.L. 1972. The cytotaxonomy of some species of *Hibiscus*. Kew Bull. 27:425–433 + 2 plates.

KRAPOVICKAS, A. 1950. Revisión del género *Lecanophora* (Malvaceae). Darwiniana 9:248–279.

KRAPOVICKAS, A. 1957. Números cromosómicos de Malváceas americanas de la tribu Malveae. Rev. Agronom. Noroeste Argent. 2:245–260.

KRAPOVICKAS, A. 1969. Notas citotaxonómicas sobre Malváceas. Bonplandia 3:9–24.

KRISHNAPPA, D.G. and Munirajappa 1980. IOPB chromosome number reports. Taxon 29:536.

MENZEL, M.Y. and F.D. WILSON. 1969. Genetic relationships in *Hibiscus* sect. *Furcaria*. Brittonia 21:91–125.

NIIMOTO, D.H. 1966. Chromosome numbers of some *Hibiscus* species and other Malvaceae. Baileya 14:29–34.

PALACIOS, R.A. and I.N. TIRANTI. 1966. Número cromosómico de especies argentinas de *Cienfuegosia* Cav. (Malváceas). Inst. Nacional de Tecnología Agropecuaria, Bol. No. 40. (9 pp. + 6 figs.)

SKOVSTED, A. 1935. Chromosome numbers in the Malvaceae. I.J. Genet. 31:263–296.

SKOVSTED, A. 1941. Chromosome numbers in the Malvaceae. II. Compt. Rend. Trav. Lab. Carlsberg, ser. Physiol. 23:195–242.

WEBBER, J.M. 1936. Chromosomes in *Sphaeralcea* and related genera. Cytologia 7:313–323.

WILSON, F.D. and P.A. FRYXELL. 1970. Meiotic chromosome numbers of *Cienfuegosia* species and hybrids and *Hampea* species. Bull. Torrey Bot. Club 97:367–376.